

AEROLOGICAL SUMMARY

[Aerological Division, D. M. LITTLE in Charge]

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The results of 578 upper-air observations made in the United States, Canal Zone, and Hawaii, by airplanes and radiosonde during March 1939 are shown in tables 1 and 1a. Free-air pressures and temperatures, as well as the March resultant-wind directions and forces, are indicated on charts VIII, IX, X, and XI, and isentropic data are shown on chart XII. Tables 2 and 3 present certain selected observations obtained by pilot-balloons in the upper air. A detailed description of these data will be found in the January 1939 issue of the MONTHLY WEATHER REVIEW.

The weather in March was, in general, abnormally warm. Mean monthly temperatures at the surface ($^{\circ}\text{F.}$) were above normal everywhere, except locally in the Northeast, upper Lake region, western Colorado, and the southern Pacific coast. Departures from normal were excessive by as much as $+6^{\circ}\text{F.}$ over the Middle Atlantic States and Ohio Valley, as well as the northern Rocky Mountain region. Precipitation was less than normal in the South, northern Great Plains, and west of the Rockies. Elsewhere, and particularly in the Northeast and in a belt across the country from the interior of the Middle Atlantic States to the southern Rocky Mountains, precipitation was unusually heavy.

In the lower levels of the free air (up to 5 kilometers) where observations are obtained both by airplane and radiosonde, most of the flights launched at the surface were very successful in reaching high altitudes. Of the 299 airplane observations made within the United States proper (table 1), 85 percent reached 5 kilometers, and 99 percent of the 217 radiosonde flights (table 1a) attained the same level. Ten kilometers was reached by 94 percent of the radiosonde observations; 55 percent went to 15 kilometers; and 24 flights (11 percent) over only 3 stations reached 18 kilometers.

An area of low atmospheric pressure prevailed during March over the Great Lakes region and along the St. Lawrence Valley eastward to Newfoundland, spreading northward indefinitely over the Hudson Bay area. This distribution is shown on charts VIII, IX, X, and XI. When compared to previous observations in the United States, this area exhibited slightly lower pressures than existed in March 1938. Elsewhere, however, pressures at 1.5, 3, 4, and 5 kilometers, were higher than a year ago, except over Washington, D. C., at all levels, and Pensacola, Fla., at 5 kilometers. Highest pressure prevailed during March over Pensacola, Fla., with slightly lower tendencies at El Paso, Tex., San Diego, Calif., and Oklahoma City, Okla., at all levels. Above 5 kilometers, where only radiosonde observations were obtained, pressures remained lowest over Sault Ste. Marie, Mich., and Fargo, N. Dak., at all levels. Computation of 5,000-foot pressures (chart VIII) for the western States, showed that a slight high-pressure area was centered over southwestern Colorado, and another over southern Nevada.

Sault Ste. Marie, Mich., reported the lowest free-air temperatures ($^{\circ}\text{C.}$) at all levels below 5 kilometers, as shown on charts VIII, IX, X, and XI, and in tables 1 and 1a. Above 5 kilometers, the lowest temperature reported in March was -66.0°C. over Oklahoma City, Okla., at 17 kilometers. The second coldest station in the higher levels was Washington, D. C. Below 5 kilometers, highest temperatures prevailed over Pensacola, Fla., and at El Paso, Tex., at 1.5, 2, and 2.5 kilometers.

At 5 kilometers, Salt Lake City, Utah, was 8.0°C. warmer in March than during the previous month, and Fargo, N. Dak., Omaha, Nebr., Spokane, Wash., El Paso, Tex., Cheyenne, Wyo., and Billings, Mont., all were at least 5.0°C. warmer than in February. Also, the above stations, as well as others, except Fargo, N. Dak., and Omaha, Nebr., were warmer during the current month than a year ago in March 1938; Spokane, Wash., being as much as 6.8°C. higher. In the very high levels it was found that Oklahoma City, Okla., was warmer than in February up to 11 kilometers, and then colder above. In addition, Omaha, Nebr., and Sault Ste. Marie, Mich., were colder in March above 10 kilometers, and Fargo, N. Dak., was colder above 11 kilometers. Washington, D. C., and Nashville, Tenn., were colder in March only at 8, 9, and 10 kilometers. But Oakland, Calif., was warmer at all levels from the surface to 18 kilometers in March.

Since March is the seasonal opposite of September, a brief comparison of high-altitude temperatures over stations which by now have conducted radiosonde observations during both periods, is interesting. It was noted that at Nashville, Tenn., Oakland, Calif., Oklahoma City, Okla., Omaha, Nebr., Sault Ste. Marie, Mich., and Washington, D. C., temperatures during March were decidedly lower than in September 1938 at the surface, ranging from 5.7°C. colder at Oakland, Calif., to 19.8°C. less at Fargo, N. Dak. However, at these stations, with the exception of Sault Ste. Marie, Mich., the differences between March and September decreased steadily with altitude until 13 kilometers had been reached over Omaha, Nebr., and Fargo, N. Dak., and 14 kilometers at Nashville, Tenn., Oakland, Calif., Oklahoma City, Okla., and Washington, D. C. At those levels March temperatures became warmer than in September, and increased steadily with altitude until the maximum height was reached in each case. However, over Sault Ste. Marie, Mich., March was colder at all levels from the surface up to the maximum of 16 kilometers.

Mean relative humidities were moderate in most cases during March. The highest occurred over Sault Ste. Marie, Mich., and Fargo, N. Dak., at all levels, being 72 percent over the former station at 7 kilometers. Lowest humidity was located over El Paso, Tex., at all levels (32 percent at 2.5 kilometers) and over Oklahoma City, Okla. (34 percent), at 8 kilometers.

The March resultant wind directions and forces, computed for 106 stations in the United States, Canada, Mexico, Cuba, and Bermuda, are shown on charts VIII, IX, X, and XI (1.5, 3, 4, and 5 kilometers, respectively). This represents an increase of 2 stations in the United States (Birmingham, Ala., and Little Rock, Ark.), and 2 in Canada (Regina, Saskatchewan, and Toronto, Ontario). The Weather Bureau, at the close of March, was conducting regular pilot-balloon observations from 85 stations within the United States proper. A selected list of certain stations for which resultants are computed, based on 5 p. m., E. S. T., observations, is given in table 2.

There was a substantial increase in the number of observations made during the current month. Compared to February this increase was 8, 18, and 26 percent at 3, 4, and 5 kilometers, respectively. Also, it was found that 76 percent of the original observations launched at the surface (table 2) reached 2.5 kilometers over all stations, and that 71 percent of these stations continued their observations up to 5 kilometers but with only 39

percent of the original flights reaching that elevation. March resultant wind directions having southwesterly components predominated below 1.5 kilometers, but above that level winds from the northwest quadrant ranged from 53 percent of the total at 2 kilometers to 89 percent at 8 kilometers. This was due, in part, to the seasonal change over the preceding month of February when observations having northwesterly components predominated, reaching 65 percent of the total at 3 kilometers and 100 percent at 8 kilometers.

The mass movement of the air at 1.5 kilometers (chart VIII) across the northern portion of the United States and southern Canada was from the northwest quadrant during March at considerably more than one-half of the stations in the country, and from the southwest quadrant elsewhere, except for several places in southern Florida, Cuba, and Mexico. At those stations southeasterly resultant directions were noted. Comparing the 5 a. m., E. S. T., March resultant directions at certain stations with the normals computed for 1.5 kilometers, it was noted that the directions at Key West, Fla., and Houston, Tex., departed from the normal in a counterclockwise rotation by 88° and 66° , respectively. The current directions at Seattle, Wash., and San Diego, Calif., departed clockwise from normal by 22° in each case. But the resultant wind directions at Nashville, Tenn., Billings, Mont., St. Louis, Mo., Cincinnati, Ohio, Boston, Mass., and Spokane, Wash., were normal or very close to normal.

At 3 kilometers (chart IX) the a. m. resultant winds showed that at 67 percent of the stations in the United States the winds had northwesterly directions. These also occurred in southern British Columbia in all cases. But a belt across the southern portion of the United States was composed of wind directions having southwesterly components. It was noted that several places for which resultant normals have been computed showed outstanding departures. Key West, Fla., had the largest variation of any—the difference between the current month and its normal being 158° , with the March resultant rotated from normal in a counterclockwise direction. Similar conditions existed at Medford, Oreg., and Houston, Tex., respectively, where differences of 73° and 52° occurred. All but two of the stations with normals showed that current directions departed from normal by counterclockwise rotations. The directions at Fargo, N. Dak., Nashville, Tenn., Atlanta, Ga., Spokane, Wash., and Omaha, Nebr., however, remained very close to their normals during March.

Resultant wind directions for March at 4 and 5 kilometers fell within the northwest quadrant at 74 percent of all stations at both levels (charts X and XI). Although the winds at 4 and 5 kilometers are based on observations made at 5 p. m., E. S. T., a comparison with the a. m. normal resultants for certain of these stations has been made. The directions at Medford, Oreg., San Diego, Calif., Key West, Fla., and Billings, Mont., showed abnormal departures, being as much as 70° , 54° , 45° , and 7° at 4 kilometers, and 68° , 47° , 36° , and 30° , at 5 kilometers, respectively. In addition, when the p. m. resultant directions for March at all levels (table 2) were compared with the a. m. normals, it was found that San Diego, Calif., Medford, Oreg., Houston, Tex., Omaha, Nebr., Salt Lake City, Utah, Oklahoma City, Okla., Seattle, Wash., and Fargo, N. Dak., showed outstanding departures. However, at Medford, Oreg., there was an average departure of 55° at each level, and all, with the exception of 3 kilometers, departed from normal by clockwise rotations, or toward the north. Cheyenne, Wyo.,

had the smallest average departure for the month. The departures at 12 such stations representing most of the country, particularly the entire central portion, were clockwise with northerly tendencies, at all levels including the surface, while only two stations had departures at all levels that were counter-clockwise rotations from normal.

In this connection, too, it was found that when comparing 5 a. m. observations with those made at 5 p. m., the resultant directions at 1.5 kilometers (at 70 percent of the stations) were slightly north (when rotated clockwise) of those reported at 5 p. m. Practically the same condition prevailed at 3 kilometers, but at fewer stations. Rather wide differences between the a. m. and p. m. March resultants at 1.5 kilometers were noted at Miami, Fla. (177° —when rotated counterclockwise); San Diego, Calif. (167° —clockwise); Las Vegas, Nev. (138° —clockwise); Reno, Nev. (93° —counterclockwise); Oklahoma City, Okla. (47° —clockwise); and El Paso, Tex. (44° —clockwise). The variations at 3 kilometers were less pronounced, the greatest being at Miami, Fla. (61° —clockwise); Medford, Oreg. (39° —counterclockwise); Charleston, S. C. (30° —counterclockwise); Salt Lake City, Utah (30° —clockwise); and Boise, Idaho (29° —clockwise).

Resultant wind directions during March were more southerly than in the preceding month of February over the entire Rocky Mountain region and the Pacific coast, while east of that area, to the Mississippi Valley and between the Canadian border and Gulf coast, all directions were more northerly than in February. Elsewhere, over the eastern third of the country, the March wind directions failed to differ so definitely and uniformly from those recorded during February.

The resultant velocities for March were decidedly lower over more than 75 percent of all stations in the country at 1.5, 3, 4, and 5 kilometers than during the previous month of February. In a great many cases the current velocities were less than one-half of those recorded in the preceding month. Similar conditions existed in Canada, Mexico, and Cuba. Although current resultant velocities were much lower than in February, when they were compared to the normal velocities at certain stations, the March velocities were higher than normal at 80 percent of the stations for which normals have been computed. This was particularly noticeable in the higher levels. At a number of these stations the current velocity ranged from 3 to 13 meters per second greater than normal.

The highest resultant-wind velocities during March were found over the eastern and central portions of the United States and southern Canada at 1.5 kilometers, particularly over the middle Atlantic States and Ohio. At 3 kilometers the highest velocities spread westward to the Continental Divide, and then elsewhere over the country, except at a few Pacific coast stations at 4 and 5 kilometers. Highest velocities at all levels were located over the East and Northeast. The current resultant velocities at 1.5 kilometers were decidedly lower over 70 percent of the stations at 5 p. m., E. S. T. (table 2), than at 5 a. m., E. S. T. (chart VIII), but at 3 kilometers the opposite was true, with most of the stations having higher velocities at 5 p. m. than at 5 a. m.

Table 3 gives the maximum actual velocities recorded over the United States. The highest noted below 2.5 kilometers (42.5 meters per second) occurred over Pittsburgh, Pa., on the 6th; that between 2.5 and 5 kilometers (62.4 meters per second) was recorded over Winnemucca, Nev., on the 12th; and above 5 kilometers a velocity of 80.0 meters per second (178.9 miles per hour) was observed at Las Vegas, Nev., on the 9th at approximately 10 kil-

ometers. This is the third time a very high velocity has been recorded at Las Vegas, Nev. The previous cases occurred in February 1939 and December 1937, and the current wind speed is believed to be the highest ever recorded in March over the United States.

MEAN MONTHLY ISENTROPIC CHART

The mean monthly isentropic chart (chart XII) for March 1939, $\theta=297$, is characterized by four very pronounced moist tongues. However, except to the extreme

north and east of these tongues there are no significant positive departures in precipitation. In fact, the whole southeastern part of the country is characterized by pronounced drought. However, it is to be noted that where the winds appear to be flowing upslope, the negative departures in precipitation are much smaller.

The patterns on the March mean isentropic charts for 1935, 1936, and 1937, correspond much more closely with the precipitation departures than do the March 1939 patterns.

TABLE 1.—Mean free-air barometric pressures (*P.*) in mb., temperatures (*T.*) in °C., and relative humidities (*R. H.*) in percent obtained by airplanes during March 1939

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																														
	Surface			500			1,000			1,500			2,000			2,500			3,000			4,000			5,000						
	Number of obser- vations	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.	P.	T.	R. H.						
Billings, Mont. (1,090 m.)	31	891	-0.7	73							847	+1.3	61	796	-1.2	61	747	-4.2	63	701	-7.5	63	616	-14.1	60	538	-21.1	56			
Cheyenne, Wyo. (1,873 m.)	30	810	-1.9	74										797	1.6	60	749	-0.3	56	703	-3.7	56	618	-11.4	56	542	-18.9	53			
Chicago, Ill. (187 m.)	30	996	0.3	76	958	0.5	73	900	-0.6	68	845	-1.0	56	794	-2.8	53	745	-4.9	52	699	-7.3	55	614	-12.8	56	538	-18.6	53			
Coco Solo, C. Z. ¹ (15 m.)	31	1,012	25.1	81	958	21.5	91	904	18.3	86	852	15.8	77	804	13.5	72	757	12.3	52	713	10.1	37	631	3.9	25	559	-4.5	45			
El Paso, Tex. (1,193 m.)	31	882	9.8	35							851	12.0	33	801	9.4	34	754	6.6	32	709	3.3	34	626	-3.5	34	550	-10.3	33			
Lakehurst, N. J. ¹ (39 m.)	25	1,015	1.3	76	958	0.5	71	900	-1.1	68	846	-2.5	64	793	-4.3	62	744	-6.3	60	698	-8.5	55	612	-13.9	53						
Norfolk, Va. ¹ (10 m.)	22	1,020	8.6	72	962	9.2	55	905	6.7	48	851	4.6	41	800	2.8	34	752	0.4	35	706	-2.6	36	622	-8.7	33	546	-15.6	32			
Pearl Harbor, T. H. ¹ (6 m.)	31	1,015	20.0	83	960	19.5	76	905	16.6	76	853	14.1	73	803	12.3	61	756	11.1	48	712	9.0	38	630	3.7	34						
Pensacola, Fla. ¹ (13 m.)	21	1,021	12.7	83	963	14.0	66	908	12.0	60	855	10.7	50	805	8.1	50	757	5.7	44	712	3.6	35	629	-2.5	27	553	-8.8	31			
St. Thomas, V. I. ¹ (8 m.)																															
Salt Lake City, Utah (1,288 m.)	31	872	2.3	76							849	5.1	62	799	2.8	59	750	-0.5	61	705	-4.2	65	620	-11.0	70	543	-16.8	60			
San Diego, Calif. ¹ (10 m.)	27	1,017	10.6	85	960	10.2	82	904	9.2	72	851	7.6	63	800	5.6	56	753	3.1	51	707	0.5	48	624	-5.7	45	548	-13.2	44			
Seattle, Wash. (10 m.)	21	1,015	7.4	72	956	4.4	70	900	3.0	59	845	0.5	57	794	-2.4	53	745	-5.7	50	699	-8.9	45	613	-15.8	47						
Spokane, Wash. (597 m.)	30	947	1.2	84							901	3.1	73	847	1.0	65	796	-1.8	59	747	-5.0	59	700	-8.3	57	615	-14.9	57	538	-21.1	54

¹ Navy.

² Flights discontinued temporarily.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 1a.—Mean free-air barometric pressures (*P.*) in mb., temperatures (*T.*) in °C., and relative humidities (*R. H.*) in percent obtained by radio-sonde during March 1939

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																							
	Fargo, N. Dak. (274 m.)			Nashville, Tenn. (180 m.)			Oakland, Calif. 2 (m.)			Oklahoma City, Okla. (391 m.)			Omaha, Nebr. (300 m.)			Sault Ste. Marie, Mich. (221 m.)			Washington, D. C. (13 m.)					
	Number of observations	P.	T.	R. H.	Number of observations	P.	T.	R. H.	Number of observations	P.	T.	R. H.	Number of observations	P.	T.	R. H.	Number of observations	P.	T.	R. H.	Number of observations	P.	T.	R. H.
Surface	31	985	-8.5	88	31	997	8.2	72	31	1,019	8.4	87	31	971	7.6	69	31	982	0.9	78	31	990	-0.9	90
500	31	957	-5.4	82	31	959	9.3	65	31	960	7.2	86	31	958	8.7	66	31	955	-2.0	73	31	955	-9.3	92
1,000	31	898	-5.2	74	31	903	7.6	64	31	903	7.0	73	31	903	9.3	59	31	901	2.1	66	31	895	-0.7	88
1,500	31	842	-5.9	67	31	850	5.5	62	31	850	5.5	62	31	850	7.7	51	31	847	1.2	62	31	838	-10.7	83
2,000	31	790	-7.3	64	31	799	3.5	59	31	799	2.9	59	31	799	5.4	47	31	795	-0.6	56	31	786	-12.3	78
2,500	31	741	-9.3	62	31	751	1.1	57	31	751	0.3	58	31	751	2.5	47	31	747	-3.1	54	31	735	-14.1	76
3,000	31	694	-11.8	61	31	706	-1.4	57	31	705	-2.8	58	31	706	-0.4	45	31	701	-5.9	53	31	688	-15.6	76
3,500	31	608	-17.6	61	31	622	-6.9	53	31	621	-8.7	55	31	622	-6.3	42	31	616	-12.1	49	31	603	-20.1	75
4,000	31	532	-23.8	59	31	546	-12.9	50	31	545	-15.3	55	31	547	-12.8	39	31	540	-18.8	46	31	526	-26.1	72
5,000	31	462	-31.0	60	31	478	-19.1	49	31	477	-21.9	50	31	479	-19.6	35	31	471	-25.6	44	31	457	-32.8	71
6,000	31	400	-38.2	58	31	418	-25.9	49	31	416	-28.9	47	31	418	-26.3	34	31	409	-33.0	43	31	395	-39.2	72
7,000	31	343	-46.2	---	29	363	-33.0	47	31	361	-36.4	45	31	363	-33.7	34	31	354	-40.2	42	31	341	-45.8	---
8,000	31	296	-52.4	---	29	314	-40.7	45	31	311	-43.7	44	31	314	-41.3	---	31	305	-47.0	---	28	293	-51.8	---
9,000	31	254	-56.6	---	29	270	-48.0	---	31	268	-50.2	---	31	270	-48.8	---	31	262	-52.9	---	27	250	-55.9	---
10,000	29	216	-59.2	---	28	232	-54.0	---	31	230	-55.1	---	31	232	-55.2	---	31	224	-57.0	---	21	214	-59.4	---
11,000	27	184	-60.3	---	27	198	-57.7	---	29	196	-57.7	---	22	198	-57.5	---	30	191	-58.6	---	19	182	-60.2	---
12,000	24	157	-69.4	---	26	169	-57.9	---	23	167	-57.6	---	20	168	-58.6	---	26	165	-57.6	---	17	155	-59.1	---
13,000	21	133	-58.6	---	26	144	-58.3	---	20	142	-57.7	---	17	144	-59.7	---	25	139	-58.0	---	14	132	-58.4	---
14,000	17	113	-58.9	---	21	123	-59.6	---	19	121	-58.9	---	13	122	-62.5	---	20	118	-60.1	---	13	113	-59.6	---
15,000	15	96	-59.4	---	18	104	-60.6	---	13	104	-60.2	---	9	104	-65.0	---	17	100	-61.6	---	8	95	-60.8	---
16,000	11	81	-59.0	---	12	89	-60.1	---	9	88	-61.0	---	6	88	-66.0	---	14	85	-61.8	---	---	---	---	---
17,000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
18,000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
19,000	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

¹ Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels, also, the humidity data is not used in daily observations when the temperature is below -40° C.

TABLE 2.—Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during March 1939

[Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second (superior figures indicate number of observations)]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)		Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (302 m.)		Billings, Mont. (1,095 m.)		Boise, Idaho (850 m.)		Brooklyn, N. Y. (15 m.)		Brownsville, Tex. (7 m.)		Buffalo, N. Y. (220 m.)		Burlington, Vt. (132 m.)		Charleston, S. C. (18 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill. (192 m.)		Cincinnati, Ohio (157 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface.....	204	3.9 ³¹	280	2.9 ³¹	273	2.4 ³⁷	251	2.6 ³¹	309	1.1 ³¹	274	3.3 ³⁷	121	4.8 ³⁰	259	3.4 ³⁷	299	1.0 ³⁸	192	1.5 ³¹	286	3.1 ³⁸	253	2.8 ³⁷	250	2.2 ³⁹
500.....	206	4.8 ³⁰	280	2.9 ³¹	278	3.0 ³⁷	251	2.6 ³¹	309	1.1 ³¹	274	3.3 ³⁷	132	5.8 ³⁰	256	6.0 ³⁷	253	2.7 ³⁸	208	3.9 ³⁰	286	3.1 ³⁸	243	4.1 ³⁷	251	4.6 ³⁹
1,000.....	220	5.6 ³²	277	3.5 ³²	256	3.8 ³⁷	252	3.7 ³⁰	299	1.5 ³¹	285	9.5 ³⁴	151	4.9 ³²	251	8.9 ³²	259	5.7 ³⁷	224	5.9 ³³	251	7.8 ³²	249	6.1 ³⁶	251	5.7 ³⁴
1,500.....	240	7.3 ³²	277	3.5 ³²	253	6.2 ³⁵	252	3.7 ³⁰	285	2.0 ³¹	286	12.0 ³²	187	2.8 ³³	258	8.7 ³⁰	264	8.2 ³³	251	7.8 ³²	256	10.3 ³²	269	8.0 ³³	260	9.5 ³⁷
2,000.....	252	9.6 ³⁷	266	4.6 ³¹	263	8.2 ³³	272	6.5 ³⁴	282	2.8 ³⁰	287	14.7 ³⁶	230	3.1 ³⁰	271	12.0 ³¹	285	9.7 ³⁷	258	10.3 ³²	290	4.5 ³⁸	278	10.9 ³²	276	12.6 ³²
2,500.....	259	11.5 ³⁴	267	6.4 ³⁴	274	10.3 ³²	274	8.5 ³⁷	269	4.6 ³⁷	288	19.0 ³⁷	242	5.1 ³⁷	280	14.3 ³¹	289	12.4 ³⁰	264	11.8 ³¹	292	7.9 ³⁸	286	13.4 ³⁹	278	14.8 ³⁹
3,000.....	262	15.3 ³¹	277	10.9 ³²	279	11.3 ³⁰	281	9.5 ³⁶	276	5.1 ³⁵	293	25.0 ³⁵	238	4.9 ³²	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷
4,000.....	261	18.6 ³¹	280	14.0 ³¹	281	15.8 ³⁷	285	12.2 ³²	287	6.0 ³⁹	288	25.0 ³⁵	255	5.1 ³¹	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷
5,000.....	262	22.5 ³⁵	275	17.0 ³⁹	281	15.8 ³⁷	287	13.9 ³⁷	305	4.2 ³¹	288	25.0 ³⁵	255	5.1 ³¹	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷
6,000.....	262	22.5 ³⁵	275	17.0 ³⁹	281	15.8 ³⁷	287	13.9 ³⁷	305	4.2 ³¹	288	25.0 ³⁵	255	5.1 ³¹	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷
8,000.....	262	22.5 ³⁵	275	17.0 ³⁹	281	15.8 ³⁷	287	13.9 ³⁷	305	4.2 ³¹	288	25.0 ³⁵	255	5.1 ³¹	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷
10,000.....	262	22.5 ³⁵	275	17.0 ³⁹	281	15.8 ³⁷	287	13.9 ³⁷	305	4.2 ³¹	288	25.0 ³⁵	255	5.1 ³¹	281	14.3 ³¹	289	12.4 ³⁰	274	10.2 ³³	294	8.9 ³⁷	287	16.4 ³⁷	287	17.5 ³⁷

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)		Fargo, N. Dak. (283 m.)		Greensboro, N. C. (271 m.)		Havre, Mont. (766 m.)		Houston, Tex. (21 m.)		Huron, S. Dak. (393 m.)		Las Vegas, Nev. (570 m.)		Little Rock, Ark. (82 m.)		Medford, Oreg. (410 m.)		Miami, Fla. (10 m.)		Minneapolis, Minn. (261 m.)		Nashville, Tenn. (194 m.)		New Orleans, La. (19 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface.....	268	3.0 ³¹	346	2.2 ³⁰	254	3.0 ³⁹	275	1.8 ³⁸	154	2.9 ³⁹	321	2.6 ³¹	122	1.4 ³¹	196	0.9 ³⁰	302	1.0 ³⁰	115	4.0 ³¹	310	1.3 ³⁰	240	1.7 ³⁰	151	1.5 ³¹
500.....	268	3.0 ³¹	346	2.2 ³⁰	254	3.0 ³⁹	275	1.8 ³⁸	154	2.9 ³⁹	321	2.6 ³¹	122	1.4 ³¹	196	0.9 ³⁰	302	1.0 ³⁰	115	4.0 ³¹	310	1.3 ³⁰	240	1.7 ³⁰	151	1.5 ³¹
1,000.....	262	3.1 ³¹	304	7.6 ³⁸	258	8.2 ³⁵	262	7.2 ³⁵	174	3.9 ³⁴	324	3.2 ³⁰	122	1.4 ³¹	224	3.5 ³¹	269	1.0 ³⁰	136	2.1 ³¹	308	3.3 ³⁸	236	4.7 ³⁸	215	2.0 ³⁸
1,500.....	258	4.5 ³¹	300	9.6 ³⁸	264	11.2 ³⁷	277	10.7 ³⁸	203	3.7 ³³	308	4.9 ³⁷	192	1.4 ³¹	259	4.6 ³⁵	237	1.3 ³⁰	253	0.3 ³⁰	299	6.0 ³⁸	257	5.0 ³⁵	252	1.9 ³⁸
2,000.....	257	6.4 ³⁰	296	11.7 ³⁵	275	13.4 ³⁵	283	10.9 ³¹	245	3.0 ³²	304	7.8 ³⁷	238	2.5 ³¹	274	7.0 ³³	253	1.5 ³⁰	280	1.5 ³⁰	281	10.0 ³¹	270	8.4 ³⁵	280	4.5 ³⁸
2,500.....	258	9.0 ³⁹	296	15.0 ³⁶	273	14.7 ³⁷	287	11.9 ³⁵	262	6.3 ³¹	293	8.9 ³⁸	261	2.9 ³¹	274	9.2 ³²	280	2.0 ³⁰	279	0.9 ³⁰	285	10.8 ³⁰	272	10.7 ³⁴	269	5.7 ³⁸
3,000.....	269	12.0 ³⁹	296	16.6 ³⁷	285	16.6 ³⁷	276	10.9 ³⁰	270	7.7 ³⁸	289	10.5 ³⁸	265	3.5 ³⁰	281	12.2 ³²	243	0.3 ³¹	246	1.0 ³¹	295	12.8 ³⁰	276	13.2 ³⁹	276	8.0 ³⁸
4,000.....	268	14.0 ³⁹	294	17.2 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	279	11.9 ³¹	292	12.7 ³³	260	6.1 ³⁵	287	15.1 ³⁶	4	2.2 ³⁰	273	2.4 ³¹	286	14.6 ³⁴	282	19.6 ³⁷	283	9.6 ³⁸
5,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸
6,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸
8,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸
10,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸
12,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸
14,000.....	271	16.1 ³⁷	295	20.1 ³⁶	285	16.6 ³⁷	276	10.9 ³⁰	283	12.2 ³²	290	14.5 ³⁹	259	8.2 ³⁸	287	18.6 ³⁶	5	2.4 ³⁰	278	3.3 ³¹	293	15.1 ³⁶	287	20.7 ³⁸	296	10.8 ³⁸

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Reno, Nev. (1,346 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		San Juan, P. R. (16 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)		Winslow, Ariz. (1,488 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface.....	256	4.6 ³¹	207	2.2 ³⁰	278	1.3 ³²	230	0.7 ³¹	250	2.0 ³⁹	245	0.8 ³³	278	3.9 ³²	76	7.2 ³¹	289	2.9 ³⁴	235	2.5 ³⁰	210	2.1 ³⁰	275	1.8 ³²	246	3.1 ³¹
500.....	280	2.9 ³⁰	201	2.4 ³⁰	288	2.6 ³⁵	230	0.7 ³¹	250	2.0 ³⁹	245	0.8 ³³	278	3.9 ³²	87	9.2 ³¹	283	4.7 ³⁸	226	2.5 ³⁰	262	4.7 ³⁸	262	4.7 ³⁸	262	4.7 ³⁸
1,000.....	306	1.8 ³⁷	207	3.4 ³⁰	261	4.4 ³⁸	230	0.7 ³¹	250	2.0 ³⁹	245	0.8 ³³	278	3.9 ³²	94	7.7 ³¹	264	5.6 ³⁴	242	2.6 ³¹	217	3.4 ³⁰	270	7.2 ³⁸	270	7.2 ³⁸
1,500.....	320	2.1 ³⁵	213	4.6 ³⁰	261	6.0 ³⁵	315	0.5 ³⁰	257	8.5 ³⁵	199	2.0 ³¹	145	0.4 ³²	90	5.9 ³⁵	303	6.8 ³¹	235							

TABLE 3.—Maximum free-air wind velocities (M. P. S.), for different sections of the United States based on pilot balloon observations during March 1939

Section	Surface to 2,500 meters (m. s. l.)				Between 2,500 and 5,000 meters (m. s. l.)				Above 5,000 meters (m. s. l.)						
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast ¹	41.0	WSW	2,160	6	Pittsburgh, Pa.	50.4	NW	3,170	10	Brooklyn, N. Y.	40.0	W	8,280	2	Albany, N. Y.
East-Central ²	42.5	WNW	2,440	7	Washington, D. C.	49.8	WSW	5,000	16	Greensboro, N. C.	52.0	WSW	5,760	16	Greensboro, N. C.
Southeast ³	33.8	WSW	1,420	5	Spartanburg, S. C.	45.2	W	4,530	16	Atlanta, Ga.	41.2	WNW	5,320	11	Jacksonville, Fla.
North-Central ⁴	35.4	WSW	2,090	15	Detroit, Mich.	44.4	NW	4,440	6	Huron, S. Dak.	48.0	WNW	8,400	6	Huron, S. Dak.
Central ⁵	35.6	WSW	1,450	11	Evansville, Ind.	39.8	WSW	2,800	5	Evansville, Ind.	58.4	W	10,120	2	Wichita, Kans.
South-Central ⁶	36.2	SSW	1,210	11	Fort Worth, Tex.	47.7	WSW	5,000	4	Abilene, Tex.	57.2	WSW	5,470	4	Abilene, Tex.
Northwest ⁷	27.3	W	1,380	18	Havre, Mont.	39.2	SW	3,240	12	Pendleton, Oreg.	52.0	NW	6,300	16	Billings, Mont.
West-Central ⁸	34.8	WNW	2,290	31	Cheyenne, Wyo.	62.4	SW	3,230	12	Winnemucca, Nev.	73.5	NNW	8,790	3	Redding, Calif.
Southwest ⁹	37.5	W	2,190	4	El Paso, Tex.	42.8	W	3,810	4	El Paso, Tex.	80.0	SW	9,980	9	Las Vegas, Nev.

¹ Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.² Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.³ South Carolina, Georgia, Florida, and Alabama.⁴ Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.⁵ Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.⁶ Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.⁷ Montana, Idaho, Washington, and Oregon.⁸ Wyoming, Colorado, Utah, northern Nevada, and northern California.⁹ Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—Mean altitudes and temperatures of significant points identifiable as tropopauses during March 1939, classified according to the potential temperatures (10-degree intervals between 290 and 399° A.) with which they are identified. (Based on radiosonde observations.)

Potential temperatures	Fargo, N. Dak.			Nashville, Tenn.			Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.			Sault Ste. Marie, Mich.			Washington, D. C.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature ° C.
290-299.....	6	7.7	-50.2										3	6.8	-46.0	5	6.4	-43.0			
300-309.....	9	8.4	-54.4										4	7.4	-46.2	14	7.7	-48.1	1	8.0	-42.0
310-319.....	13	10.1	-62.2	2	7.6	-32.0	2	6.4	-31.0	1	6.4	-29.0	15	9.2	-52.7	20	9.4	-55.6	6	9.2	-49.3
320-329.....	10	11.6	-68.9	14	10.2	-53.1	19	10.6	-56.1	18	10.3	-52.5	20	10.9	-60.8	10	10.6	-59.3	10	9.8	-52.0
330-339.....	5	12.4	-69.2	21	11.6	-59.1	13	11.7	-60.1	15	11.2	-55.5	9	11.4	-59.7	6	11.6	-60.8	14	11.6	-59.2
340-349.....	1	11.9	-59.0	11	11.9	-57.8	13	12.0	-56.5	8	12.0	-56.1	5	12.1	-60.0	1	12.1	-63.0	3	12.8	-64.3
350-359.....	1	11.6	-64.0	3	13.3	-60.7	1	12.1	-53.0	2	12.7	-58.0	2	12.2	-55.5	4	11.8	-54.2	4	12.0	-54.2
360-369.....				1	13.6	-61.0				4	13.6	-61.2	2	13.6	-61.0	1	11.9	-51.0	1	11.6	-53.0
370-379.....	2	14.2	-63.5	4	14.7	-64.0	1	15.3	-69.0	2	14.4	-63.5	2	14.6	-66.0	1	12.8	-51.0			
380-389.....				6	14.7	-60.6							2	15.8	-72.5	1	13.1	-60.0			
390-399.....				1	15.5	-61.0							4	15.1	-61.7	1	14.8	-58.0			
All (weighted means).....		10.2	-61.2		11.9	-57.3		10.9	-55.5		11.0	-53.1		10.9	-57.7		9.6	-53.9		10.8	-55.1
Mean potential temperature.....	318.2			343.2			331.6			331.6			331.5			321.5			332.0		